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Remington Arms Company, Inc.

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RESEARCH AND DEVELOPMENT DEPARTMENT

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AB-62-7

FINAL SUMMARY REPORT
Contract DA-19-020-ORD-5379
Project TN 1-2707
Development and Manufacture of Special Caliber .30
(Unclassified Title)
by
Fred Senko & Theodore B. Johnson

July 18, 1962
Period Covered
March 1961-March 1962

Remington Arms Company, Inc.
Bridgeport, Connecticut

for

Feltman Research and Engineering Laboratories
Picatinny Arsenal, Dover, New Jersey

Copy No. 15

Contract No. DA-19-020-ORD-5379
Project No. TN1-2707

Development and Manufacture of
Special Caliber .30 Electric Primers

Part I

Object

The general objective of this contract was to modify the caliber .30 electric primer, Type 2, so that it would be satisfactory for use with the Type T-2 explosive switch. Specifically the modified primer must possess the following characteristics:

(a) Must produce a residue after firing in a specially designed T-2 explosive switch case having a resistance equal to or greater than 300 megohms.

(b) Must produce less residue than the standard Type 2 Caliber .30 Electric Primer.

(c) Must have a functioning time of less than 15 milliseconds.

(d) The functioning primer must possess greater brisance or shattering power than that of the standard Type 2 Caliber .30 Electric Primer.

A further objective of this contract was to furnish a sample of 3,000 primers containing the optimum formulation charge type and weight.

Summary

Tests at Picatinny Arsenal with the Caliber .30 Electric Primer with the standard FA874 priming mixture indicated that, to make this primer satisfactory for operation of the Type T-2 closed-to-open explosive switch, it would be necessary to a) increase the power of the primer and b) increase the electrical resistance of the primer residue. The practical accomplishment of these objectives involved the design of a circuit for the dynamic measurement of resistance across the open switch and the evaluation of priming mixture modifications with this circuit.

A satisfactory means of measuring the resistance has been

devised. It involves the simple, direct approach of an oscilloscope trace of the voltage across a resistor in series with the switch. Evaluation of experimental priming mixtures with this technique has led to the development of a priming mixture coded XP407A. Charged at 0.27 gr. and tested in the T-2 switch with the 3Z type case this mixture shows the following improvements in performance and properties:

(1) Power of the primer is increased, resulting in improved reliability of switch functioning;

(2) Switch functioning times are 2 milliseconds or less. This easily meets the requirement of 15 milliseconds. Resistance immediately after functioning is consistently greater than 300 megohms;

(3) Resistance 15 milliseconds after firing has never been less than 50 megohms and 98% of the time was 100 megohms or higher. This does not quite meet the requirement of 300 megohms minimum, but would appear adequate for most purposes and is considerably better than with the standard primer.

(4) Primer solid residue has been reduced over 55% and final "cold" resistance is essentially open circuit almost 50% of the time, with the remainder being under 100 megohms and 2% under one megohm . This is an improvement over previous conditions, but does not meet specified aim.

(5) Sensitivity of the caliber .30 electric primer with XP407A priming mixture is within the range specified for the M52A3 primer, after which it is patterned.

3000 caliber .30 electric primers charged with approximately 0.27 gr. of XP407A priming mixture have been delivered to Picatinny Arsenal for fuller evaluation.

Conclusions

As a result of this investigation we have concluded that a priming charge has been developed for the caliber .30 electric primer which is nearly, if not entirely, satisfactory for most uses with the T-2 switch. If (a) permanent "cold" resistance of 300 megohms and for (b) greater sensitivity

are required additional work will be necessary. It appears likely that improvement in the switch or its assembly will be necessary for completely satisfactory performance.

Recommendations

If the above conclusions appear to be valid after a full evaluation of the 3000 primers delivered to Picatinny Arsenal, we recommend an investigation to:

(1) Improve final cold resistance through (a) further improvement of the resistance characteristics of the primer products and (b) improvement in the stability of the electrodes and other switch components.

(2) Improve primer sensitivity. This will involve priming mixture modifications, but some additional help may come from better control of manufacture and assembly of components.

PATENT STATEMENT

It is believed that some patentable invention was involved in the development of a priming mixture giving improved reliability of operation and less conductive residue.

An appropriate "Report of Inventions" was submitted to the Contracting Officer's Representative in the Boston Ordnance District on July 3, 1962, noting that the Contractor did not intend to file a patent application on this invention.

Part 11

Introduction

Under Picatinny Arsenal Order No. 501-59-6718 the Remington Arms Company, Inc., manufactured and delivered 500 Caliber .30 Electric Primers, Type 2, to Picatinny. The Arsenal used these primers in connection with the development of the Type T-2 closed-to-open explosive switch. The seitch functioning tests were not satisfactory because of the following shortcomings reported by Picatinny Arsenal:

(a) The primer did not develop enough pressure gradient across the normally closed circuit strip in the switch to break it reliably.

(b) The residue from the priming mixture coated the electrodes and was not sufficiently non-conductive to permit the attainment of the desired open circuit resistance of 300 megohms. At times there was enough residue to create a conducting or partially conducting path between the electrodes.

This contract was undertaken to develop a primer without the above deficiencies. In order to accomplish these objectives it was necessary to:

(1) Devise a satisfactory method of measuring the resistance across the switch electrodes as a function of time for the 15 millisecond period following application of the firing energy to the primer.

(2) Test and evaluate results with several different types and quantities of primer compositions in order to extablish the optimum.

(3) Make 3000 primers with the optimum charge.

Results

A satisfactory circuit has been designed for the dynamic measurement of resistance across the switch. (Fig. 11) The time of measurement may be varied but was generally the first 30 milliseconds after sending the initiating pulse to the primer. The point of greatest sensitivity in measurement of resistance also may be varied as desired, but the open circuit goal of 300 megohms was an obvious choice. The circuit was successfully evaluated using Caliber .30 electric primers, Type 2, with the standard FA 874 priming mixture. Table I-1 . The defeats previously noted at Picatinny Arsenal were confirmed:

(1) The switch foil strip is not always broken;

(2) Partially conductive residue sometimes bridges the switch gap.

The measurements also showed a normal primer and switch functioning time in the one millisecond range, with the resistance usually attaining the hundred mehohm range within 15 milliseconds.

Following satisfactory demonstration of the resistance measuring technique the evaluation of experimental priming mixtures was begun. Table 1,2-4. The first three mixtures tested, XP401, XP402 and XP403, showed a progressive decrease in the amount of residue. With the charge weight and experimental set-up used, none of these mixtures resulted in completely reliable breaking of the foil, although there was no visible bridging of the switch gap with residue with XP403. Additional tests (Table I-5) showed that XP403 was too powerful; even at the lowest weight that could be charged, the switch case sometimes was cracked or the electrode assembly pushed out of the switch case.

XP406 was formulated to give considerably less power than the too powerful XP403 and less residue than XP401, but, charged at 0.25 gr., there was some evidence of residue bridging the electrodes. XP407 then was formulated to reduce further the residue. At 0.24 gr. charge and 3Z switch bodies without the silver foil, results were good. There was no indication of the electrodes being bridged by residue. Table I,6-8. However, with regular 3Z switches with foil, one primer failed to completely sever the foil. Raising the charge to 0.31 gr. made the primer too powerful, although the amount and kind of residue at this

charge appeared to be satisfactory.

Initial tests with an intermediate charge of XP407 gave good results, with the switch foil being broken cleanly in each instance. Table I,(11,12.) Visual observation of the electrodes showed little residue. There was no bridging of the electrodes, although there was some indication of slight bridging between an electrode and the switch case wall. These results led to a more complete evaluation of the intermediate charge of XP407 (Table II). In these tests there were no failures out of 41 trials with the 3Z switch cases; 1Z,2Z and 4Z cases each had one or more failures to break the foil. Times to break the foils were of the order of 2 milliseconds. Mean firing voltage ($\bar{V}$) for the original XP407 primers was about 123 volts from 4 microfarads. (Table III). Increase in the acetylene black content of the mixture to 1.1% (XP407A) reduced this to about 78 volts.

Following these successful tests with XP407A at charge weights between 0.24 gr. and 0.31, the assembly of about 3300 Type 2,electric primer components was completed. As agreed to by the Project Officer, they were charged with a nominal weight of 0.27 gr. XP407A. 3000 were shipped to Picatinny Arsenal on May 3, 1962.

Discussion of Results

A. Design and Evaluation of Dynamic Resistance Measurement Equipment

The technique of resistance measurement appears to be completely satisfactory. The circuit (Fig. II) offers the flexibility of choice of the time interval over which the resistance is measured and selection of the value of resistance for maximum sensitivity. For our tests these were generally, (a) zero to thirty milliseconds after sending the firing impulse to the primer and (b) 300 megohms, respectively. A diagrammatic explanation of a typical curve obtained with this circuit is shown in Fig. III. The only difficulty encountered at all was an occasional shift of the curve due to interference of the firing circuit with the measuring circuit through mutual contact with the switch case and/or the switch holder when it was made of metal. This was of little consequence, however, as it consisted of an abrupt change in the level of voltage which could be measured and allowed for in the estimation of the resistance.

Pictures of typical curves are shown in Fig. IV. 1 and 2 illustrate results with XP407A and 3Z cases. 3 shows a failure with FA874 and a 1Z case. 4 shows the 1Z case with XP407A.

B. Switch Functioning Time

Switch functioning time, as measured by the initial

charge appeared to be satisfactory.

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B. Switch Functioning Time

Switch functioning time, as measured by the initial

abrupt change in resistance of the oscilloscope traces, appears to be satisfactory and is consistent with the known action times of electric primers of this type. With the 3Z switch case and XP407A priming mixture the functioning time was 2 milliseconds or less; the action time of M52 type electric primers, upon which the caliber .30 electric primer design is based is about 0.1 millisecond and action times of ammunition using M52 type primers is about 3 milliseconds.

C. Reliability of Switch Functioning

With the 3Z switch case and XP407(or XP407A) priming mixture at an average charge weight of 0.26 gr. or greater there were no failures to operate the switch in 49 tests. One or more failures, in a much smaller number of trials, was obtained with the 1Z,2Z and 4Z switch cases and with the standard FA874 priming mixture. The improved reliability of XP407A with the 3Z switch case is indicated, but much larger scale testing will be necessary to establish the level of reliability. In this regard it is pertinent to consider the importance of the switch assembly. Fig. V, which illustrates representative examples of successful and unsuccessful switch functioning, includes sections of two switches in which the electrodes are misaligned.(Fig. V,5 & 6). If this is far enough off so that the gap between the electrodes is not wholly under the primer flash hole a failure to function could occur. This may have contributed to these and some of the other failures encountered. For this and other reasons, discussed below, future work in this area should include the switch and primer together.

D. Resistance Across the Open Switch

In those tests in which the switch foil was broken successfully, the resistance across the switch immediately after functioning was greater than 300 megohms regardless of the mixture or switch case type. Fifteen milliseconds after pulsing the firing energy to the primer, XP407A with the 3Z switch case (Table IV-20) showed 86% (42 out of 49) at 300 megohms or higher, 98% (48 out of 49) at 100 megohms or higher and one at 50 megohms. The standard FA874 mixture and the 3Z, Table II-21 case showed only 44% (7 out of 16) at 300 megohms or higher and 69% (11 out of 16) at 100 megohms or higher; the values less than 100 include one short circuit, or failure to function, for FA874. For all four Z type switch cases combined XP407A, Table II-23, showed 9% (9 out of 103, including 4 short circuits) less than 100 megohms and FA874, Table II-22, showed about 29% (8 out of 28, including 3 short circuits) less than 100 megohms for the combined Z type switches. The superiority of the XP407 mixture-3Z switch case combination is clear and, in our opinion, is a reasonably close approximation to the contract aim of 300 megohms at 15 milliseconds.

In the case of the final resistance a substantial number (approximately 50%) of all switches tested showed a final resistance of less than 100 megohms. However, XP407 with 3Z cases showed only 2% (1 out of 49) less than one megohm, and XP407 with all Z type cases showed 9% (8 out of 103, including 4 short circuits) less than one megohm. FA874 with all Z type cases, 18% (5 out of 28, including 3 short circuits) less than one megohm. The XP407-3Z case combination appears to result in significantly higher resistances but does not consistently meet the 300 megohm requirement. We do not know how serious it would be to have a "cold" resistance in the one megohm range. These resistances were measured from 30 seconds to several minutes after firing, yet it is known that the 15 millisecond resistances of greater than 100 megohms last at least 100 milliseconds as evidenced by double trace records of 50 millisecond oscilloscope sweeps. These include samples that showed a "cold" resistance of much less than 100 megohms.

We do not know why the resistances in the one megohm range occur, but examination of sectioned fired switches suggests two factors that must be considered:

(1) An abnormal nearness of one or both electrodes to the case wall. This is known to have occurred both by movement of the electrodes during firing and by misalignment at assembly (or as received by us).

(2) Bridging between electrodes or between the case wall and an electrode by the residue from the primer.

The quantity of solid residue from the primer has been reduced from about 0.7 grain per grain to about 0.3 grain per grain, and the nature of the residue has been changed to a fine powdery deposit so that it is much less likely to form globules and result in bridging. However, some bridging has occurred with XP407 when an electrode was very close to the switch wall. Two other factors that may influence the "cold" resistance are (a) a small fine dispension of residue covering most of the inside of the switch and (b) the presence of surface moisture either from the priming mixture or by being present before firing. Future work should take all of these factors into consideration.

E. Primer Sensitivity

The formulation of XP407 as the optimum mixture for switch functioning has resulted in a sacrifice in voltage sensitivity as shown in Table III. This was due largely to a decrease in density of the mixture, resulting in a dilution of the conductive material and the initiating explosive. Increasing the weight of conductive material to 1.1% acetylene black in XP407A gave a very definite improvement in sensitivity; it is doubtful

how much more improvement in sensitivity can be made by further increase in the acetylene black content without also increasing the lead styphnate. The present sensitivity is well within the specifications for the M52A3 primer after which the caliber .30 design was patterned; for a more sensitive primer future work should include a more thorough study of sensitivity as an integral part of the investigation.

Experimental Procedure

The original resistance measuring circuit is shown in Fig. I. It gave reasonably good results, but a second circuit was designed in order to increase the sensitivity of measurement in the 300 megohm range and to provide the advantages of the cathode follower- i.e. its high impedance input and low impedance output. This circuit, Fig. II, comprises a T-2 switch in series with a 300 megohm resistor and a voltage source, with voltage being impressed across the resistor to an oscilloscope through a cathode follower. The high impedance input of the cathode follower. The high impedance input of the cathodefollower across the voltage divider network (300 megohms resistor and switch) places the point equivalent to 300 megohms switch resistance midway between the zero voltage line (closed open circuit) and the full voltage line (closed switch resistance). The voltage transient, as diagrammed in Fig. III, can be translated as resistance versus time. For our purpose an estimate of the resistance at any given time was made in a matter of minutes by the use of reference lines and a Polaroid Land camera.

Primers were fired by the discharge of an eight microfarad capacitor charged to 250 volts. The scope sweep was triggered by means of a pulse picked off of a high impedance voltage divider across the capacitor.

The switch holder design is shown in Fig. VI. This was initially made of Nylon, but repeated use damaged it and it was replaced by a steel holder of similar design. The latter was more satisfactory from the standpoint of strength, but was more prone to interaction between the primer firing circuit and the resistance measuring circuit; this was noticeable as a sudden displacement of the voltage transient. With both holders poor support of the switch resulted in one or both of the switch casualties shown in Fig. V. Poor wall support sometimes resulted in a body split, while failure to support the ends sometimes resulted in the electrode assembly being forced partly out of the body. Both of these conditions are aggravated by a primer of too great power, and the dislocation of the electrode assembly can be caused by an inadequate crimp. Some of the low final resistances encountered and at least one short circuit are attributable to electrode aasembly disruption, so it is obvious that proper switch support should be included

in any future investigation.

References

6 previous Progress Reports

TABLE 1

EVALUATION OF EXPERIMENTAL PRIMING MIXTURES

Priming Mixture and Av. Chge.	Switch Case	No. Tested	%Failure to Break Foil	% Having Resistance at 15 ms. Megohms >300	>100	%Having Final or "Cold" Resistance megohms >300	>100	>1	Remarks
1. .29 gr. FA674	3Z	12	8	42	58	75	75	83	Electrodes bridged with residue in 2 cases
2. .25 gr. XP401	3Z	6	17	67	67	67	67	83	
3. .20 gr. XP402	3Z	5	0	80	80	60	60	60	
4. .19 gr. XP403	3Z	3	67	33	33	33	33	33	Very small amount of residue
5. .29 gr. XP403	3Z	8	0	-	-	43	43	86	One short circuit due to electrode movement. 8th shot shattered holder
6. .25 XP406	3Z NF[2]	2	-	50	100	-	-	-	One electrode displaced, slight residue
7. .24 gr. XP407	3Z NF[2]	2	-	100	100	100	100	100	No damage, little residue
8. .24 gr. XP407	3Z	2	50	50	50	50	50	50	No damage, little residue
9. .31 gr. XP407	3Z NF[2]	2	-	100	100	100	100	100	One electrode damaged, little residue
10. .31 gr. XP407	3Z	2	0	100	100	100	100	100	One electrode damaged, little residue
11. .27 gr. XP407	3Z NF[2]	2	-	100	100	100	100	100	No damage. Little residue
12. .27 gr. XP407	3Z	8	0	87.5	100	75	87.5	100	No damage, slight bridging between an electrode and wall in 2 cases.

(1) Priming mixture formulas in Table 1V
(2) No foil

TABLE 11

EVALUATION OF XP407A MIXTURE

Priming Mixture (1) and Av. Chge.	Switch Case	No. Tested	%Failure to Break Foil	Resistance at 15 ms. megohms >300	Resistance at 15 ms. megohms >100	Final or "Cold" Resistance megohms >300	Final or "Cold" Resistance megohms >100	Final or "Cold" Resistance megohms >1	Remarks
1. .26 gr. XP407A	1Z	10	0	70 mg.	80 mg.	50 mg.	50 mg	100 mg.	
2. .29 gr. XP407A	1Z	9	11	89	89	33	33	78	
3. (1) & (2) combined	1Z	19	5	79	84	42	42	89	
4. .34 gr. FA874	1Z	4	50	25	25	25	25	25	Electrode gap bridged by residue in one case
5. .26 gr. XP407A	2Z	8	0	62.5	87.5	37.5	37.5	87.5	
6. .29 gr. XP407A	2Z	7	0	86	86	29	29	71	One electrode displaced and bridged by residue to case.
7. (5) & (6) combined	2Z	15	0	73	87	33	33	80	3 body splits.
8. .34 gr. FA 874	2Z	4	0	75	100	0	25	100	
9. .26 gr. XP407A	3Z NF(2)	4	-	100	100	0	0	50	
10. .26 gr. XP407A	3Z NF(2)	6	-	67	100	67	67	100	Extra crimp at electrode assembly.
11. .27 gr. XP407A	3Z	11	0	100	100	73	73	100	
12. .26 gr. XP407A	3Z	21	0	81	100	24	33	95	
13. .29 gr. XP407A	3Z	9	0	78	89	11	11	100	
14. (11) (12) & (13) combined	3Z	41	0	85	100	34	39	98	2 body splits.
15. .34 gr. FA874	3Z	4	0	50	100	50	50	100	
16. .29 gr. XP407A	4Z	11	27	55	73	27	36	73	
17. .29 gr. XP407A	4Z	9	0	67	89	56	56	100	
18. (16) & (17) combined	4Z	20	15	60	80	40	45	85	2 body splits
19. .34 gr. FA874	4Z	4	0	100	100	75	75	100	
20. (12) from Table 1 & (14)	3Z	49	0	86	98	41	47	98	
21. (1) from Table 1 plus (15)	3Z	16	7	44	69	69	69	87.5	
22. (1) from Table 1 plus (4) (8) (15) & (19)	all	28	11	54	71	54	57	82	
23. (12) from Table 1 plus (3) (7) (14) & (18)	all	103	4	68	91	40	44	91	

(1) Priming Mixture formulas in Table 1V
(2) No foil

TABLE III

Voltage Sensitivity Tests
Caliber .30 Electric Primers- Type 2

XP407- 1% acetylene black — $\bar{V}$= 123 volts

Voltage at 4 microfarads	1	2	3	4	5	6	7	8	9	10
140							F		F	
130						M		M		F
120	F				M					
110		F		M						
100			M							

XP407A- 1.1% acetylene black — $\bar{v}$= 78 volts

Voltage at 4 microfarads	1	2	3	4	5	6	7	8	9
90						F			
80			F		M		F		M
70		M		M				M	
60	M								

FA874 — $\bar{V}$= 39 volts

Voltage at 4 microfarads	1	2	3	4	5	6	7	8	9	10
50							F			
45						M		F		
40	F		F		M				F	
35		M		M						F

F= fire
M= misfire

TABLE 1V

Priming Mixture Formulas

Code and Composition
Parts by Weight

	FA874	XP401	XP402	XP403	XP406	XP407	XP407A
Normal Lead Styphnate	40.6	30	30	30	34	37	37
Barium nitrate	44.7	30			25	25	25
Calcium silicide	13.2				6		
Trinitroresorcinol	1.0						
Acetylene black	0.5						
	to	1	0.9	1	1	1	1.1
	0.1						
Pentaerythritol tetranitrate		30	60	69	34	37	37
Chromated aluminum		9	60				37

CIRCUIT - #1

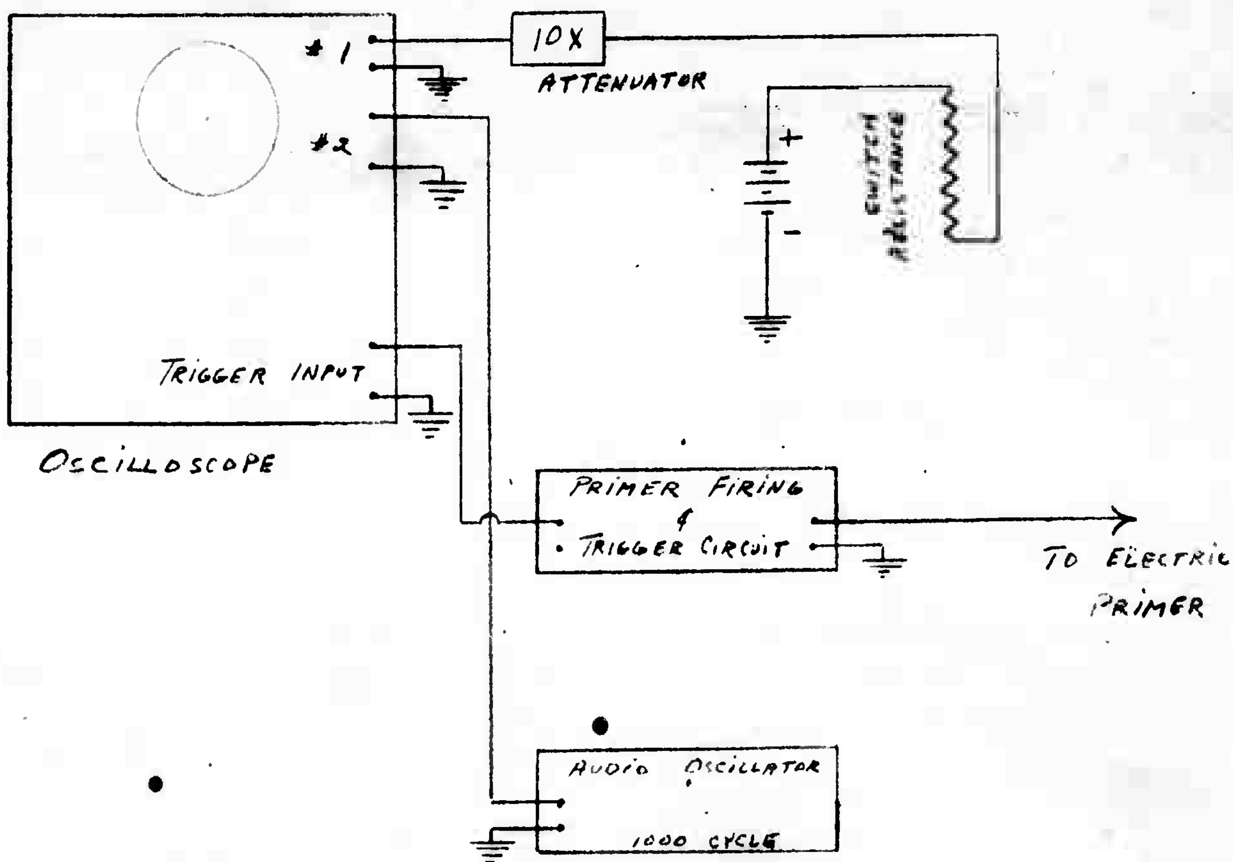


FIGURE I

MAY 17 1962

CIRCUIT #2

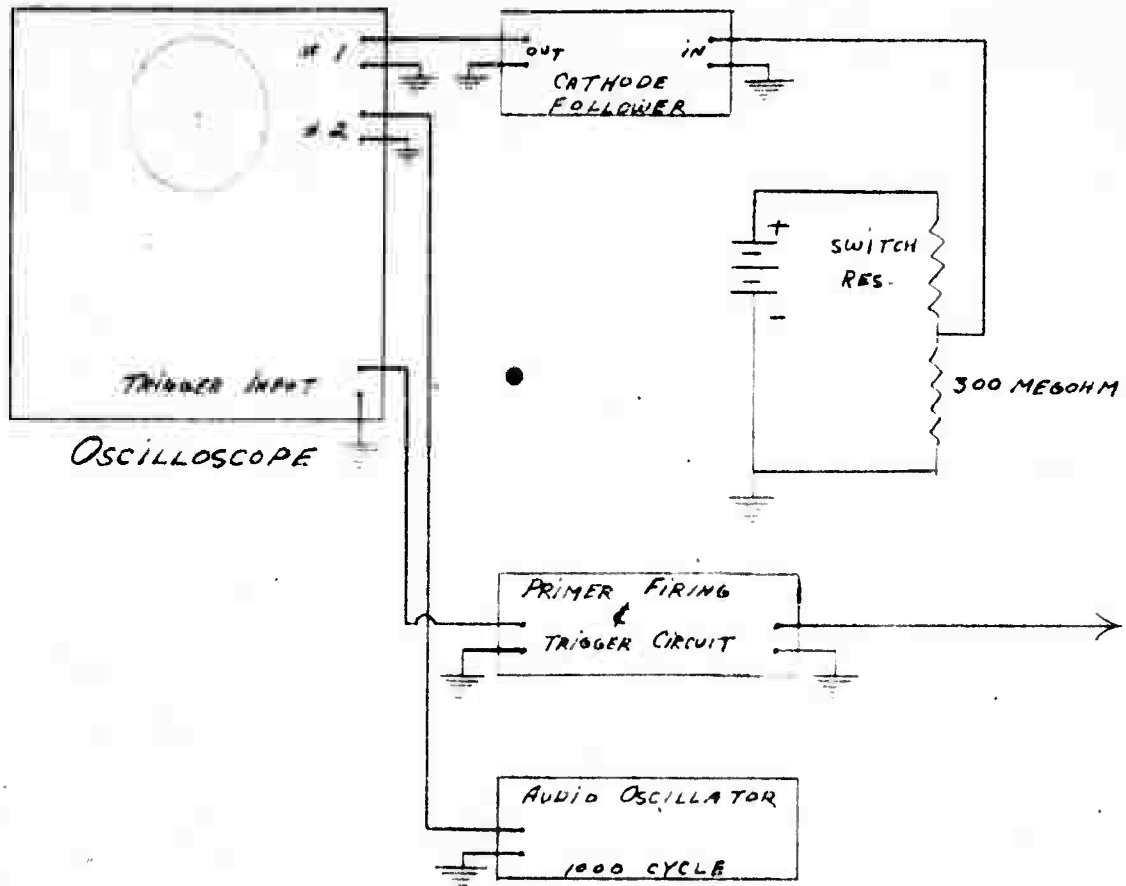


FIGURE II

MAY 17 1962

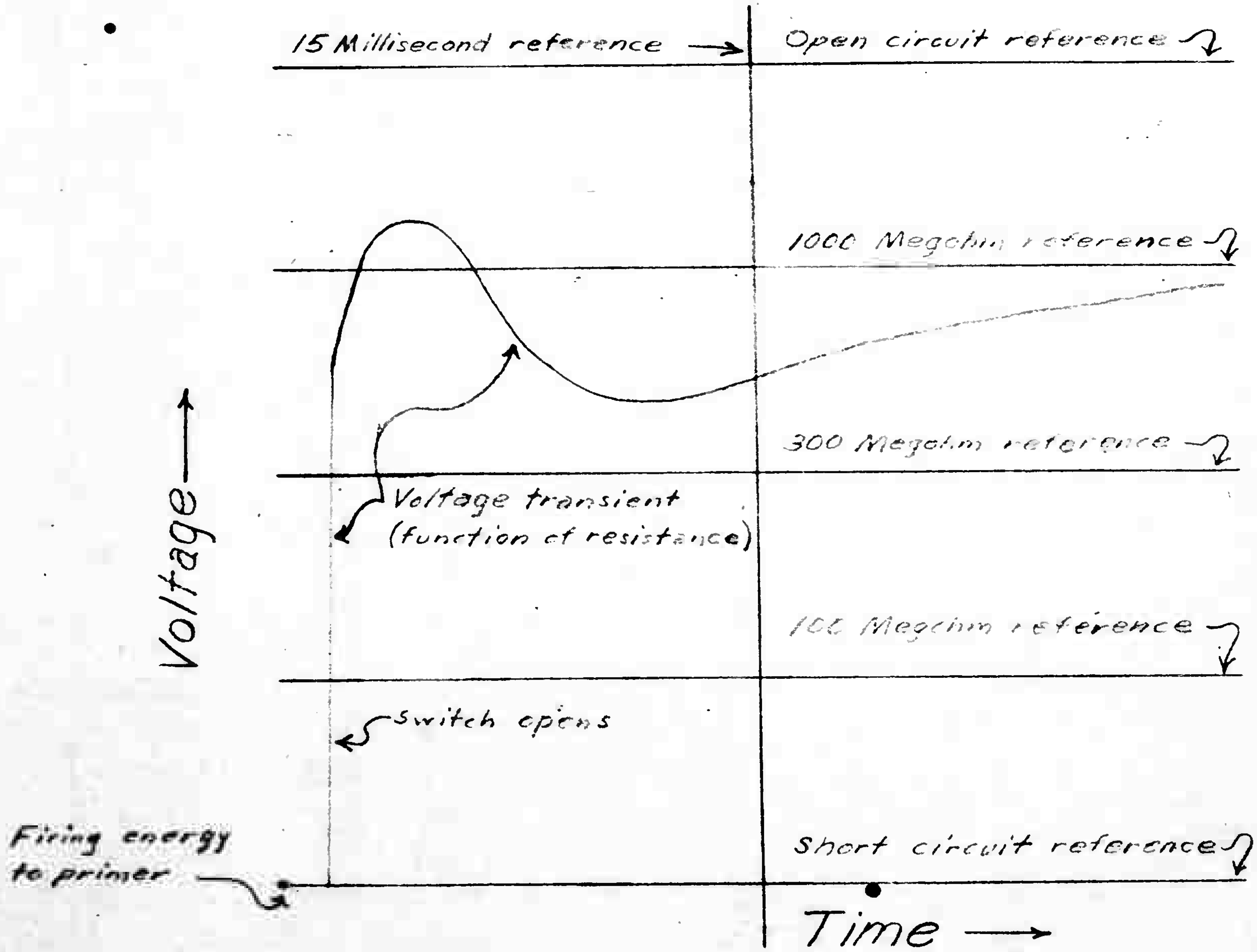
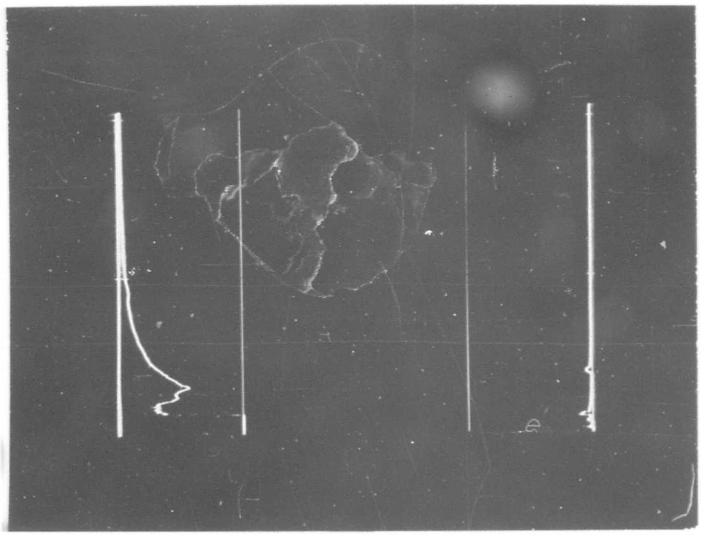
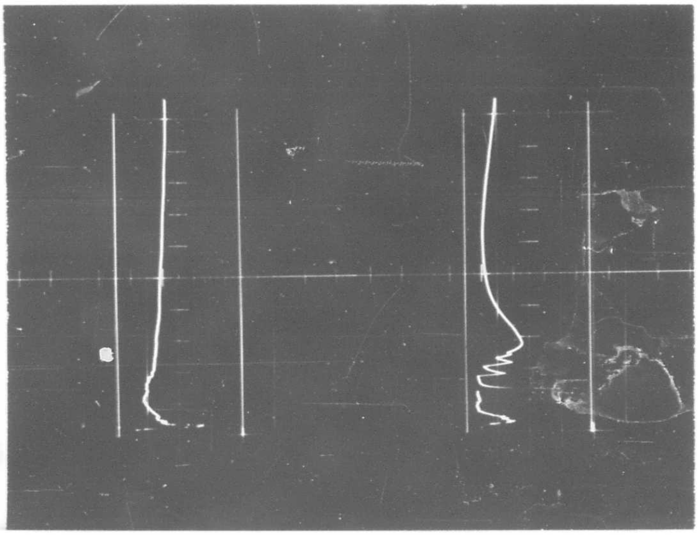

15 Millisecond reference
Open circuit reference
1000 Megohm reference
300 Megohm reference
100 Megohm reference
Short circuit reference
Voltage transient
(function of resistance)
Switch opens
Firing energy
to primer
Voltage
Time

Fig. III.

Fig. 1V

4 3

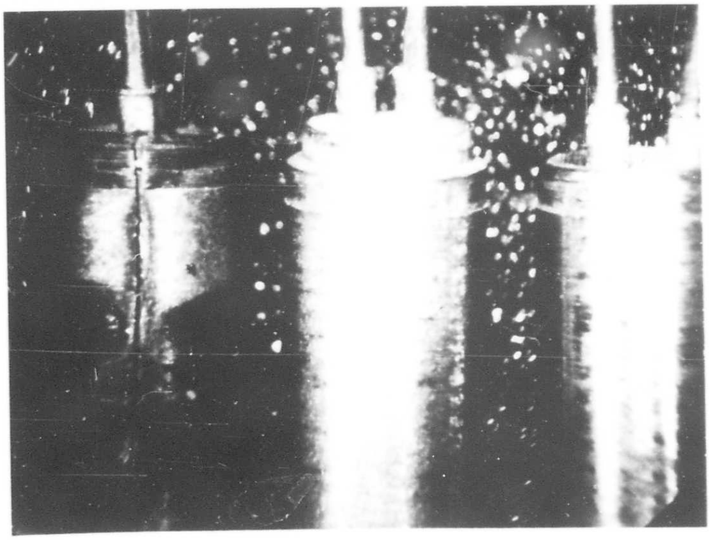


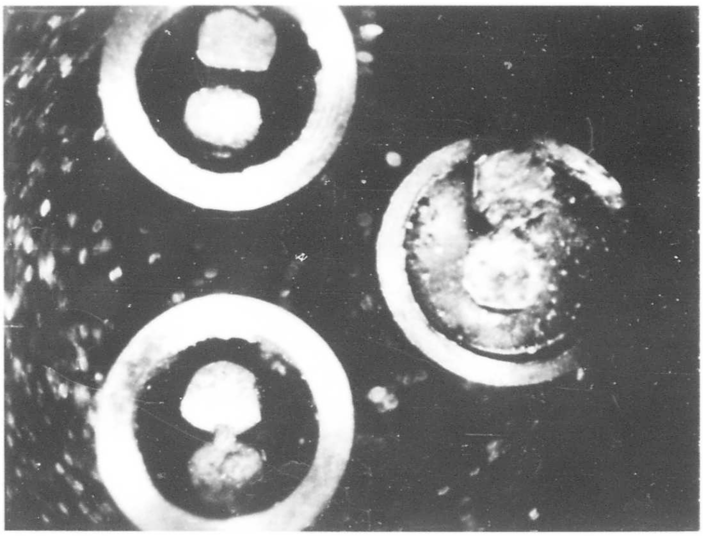


1 2

Fig. V

1 2 3





4
5 6

FIRING PIN AND SWITCH HOLDER

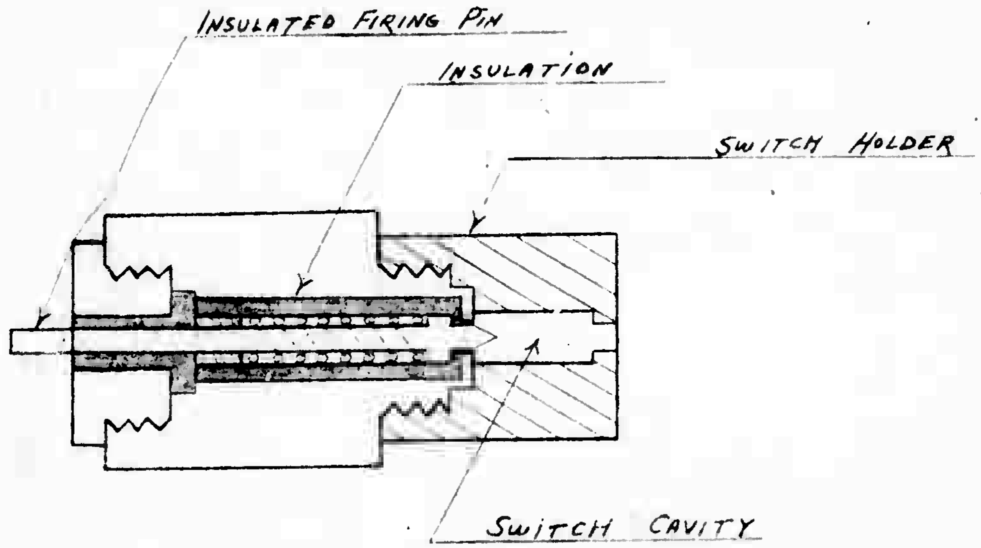


FIGURE VI

MAY 17 1962

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Armed Services Technical Information Agency Arlington Hall Station Arlington 12, Virginia.	10
Commanding Officer Boston Ordnance District Army Base Boston 10, Massachusetts ATTN: ORDEB-LD	1

AD- Accession No.-------------

Remington Arms Co., Inc., Bridgeport, Conn.
Final Summary Report No. AB-62-7
DEVELOPMENT AND MANUFACTURE OF SPECIAL CALIBER
.30 ELECTRIC PRIMERS.

Unclassified Title

Fred Senko & Theodore B. Johnson 22p.
Contract DA-19-020-ORD-5379
Department of the Army Project No. TN1-2707
Research and Development, OCO, July 18, 1962
Tests were made on Type T2, normally closed,
explosive switch to improve switch opening char-
acteristics. This type of switch is fired by the
explosive action of a special electric primer.
Brisance of the primer and the electrical resis-
tance of the primer residue were both increased.
Quantity of primer residue was decreased. Sensi-
tivity and functioning time of the primer remain
satisfactory. Recommendations are made for further
improvement if required. Unlimited Distribution

AD- Accession No.----------

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